Pak. J. Bot., 42(4): 2793-2801, 2010.

MAIZE RESPONSE TO INTEGRATED USE OF NP-FERTILIZERS AND COMPOST

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Abstract

An experiment to investigate the influence of different NP-fertilizers and compost on maize plant growth was carried out in a pot experiment during 2009 at the Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan. The experiment was laid out in a complete randomized design. According to analysis of variance, the four different sole fertilizers (Urea and DAP (Di-ammonium phosphate) @ 50 and 100ppm), two fertilizer formulations (DAP + Compost @ 50 and 100ppm) and control manifested highly significant ($p \leq 0.01$) differences for mean values of maize growth parameters. Overall, the fresh root weight was 7.50 g (Urea @ 50ppm) to 15.36 g [DAP + Compost @ 100ppm], fresh shoot weight was 22.53 g (Urea @ 100ppm) to 33.93 g (DAP + Compost @ 50ppm), root length was 39.33 (DAP @ 50ppm) to 56.33 cm (Urea @ 50ppm), shoot length was 70.50 cm (DAP + Compost @ 100ppm) to 81.50 cm (DAP @ 100ppm), dry root weight was 0.67 g (Urea @ 50ppm) to 1.27 g (DAP + Compost @ 100ppm) and dry shoot weight was 2.83 g (Urea @ 50ppm) to 4.00 g (DAP + Compost @ 50ppm) among the said seven treatments. The fertilizer formulations DAP + Compost @ 50ppm and DAP + Compost @ 100ppm performed better in boosting the maize growth parameters about root and shoot. It was concluded that said fertilizer formulations can provide significant positive enhancement to maize growth as compared to sole fertilizers.

Introduction

Maize (*Zea mays* L.) is one of the most important cereal crops of the world extensively grown in irrigated and rainfed areas (Irshad *et al*., 2002). Maize is multipurpose crop and provides food for human beings, fodder for live stock and feed for poultry. It has great nutritional value as it contain about 66.70% starch, 10% protein, 4.8% oil, 8.5% fiber, 3% sugar and 7% ash (Chaudhry, 1983). It is also a quick growing crop and ranks next to wheat and rice in terms of grain production in Pakistan with average grain yield of 3427 kg ha^{-1} (Anon., 2008).

The cultivated soils of Pakistan are deficient in organic matter and in major plant nutrients such as nitrogen (N) and phosphorus (P). Low crop productivity is the common feature of agriculture in Pakistan because of very low organic matter (O.M) content, poor soil physical condition, wide spread nutrient deficiencies (Rashid, 1994), unbalanced use of fertilizers and low nutrient-use-efficiency (Anon., 2006). Cahill *et al*., (2007) studied the slow release nitrogenous fertilizers which have potential to improve yield and nitrogen use efficiency (NUE) in maize. A slow release urea formaldehyde polymer (UFP) was

compared with aqueous urea ammonium nitrate (UAN). However, the soluble N sources viz., ammonium sulfate, urea ammonium phosphate, urea and 3 slow-release sulphur-coated urea fertilizers were used at 0, 50, 100 or 200 kg ha^{-1} in maize grown in a soil having a pH value in water of 5.1. The uptake of P usually increased with increasing N rate.

For sufficient food production to sustain the huge population, cropping practices often call for large applications of nitrogen fertilizer to maximize yields. However, the N applied is not all taken by crop; the efficiencies of N fertilizer use are very low, approximately 32-35%. A large proportion is lost to the atmosphere by ammonia volatilization and denitrification, or leached into the ground or surface waters (Zhang *et al*., 2009). Similar to the denitrification loss from fertilizer N applied to wheat-maize in China of 0.8-2.0%, as estimated by Cai (2002). The annual denitrification loss was 7.3 kg N $ha^{-1}y^{-1}$, accounting for 1.02% of applied N (Zhang *et al*., 2009). Under wheat-maize rotation field there are rare root actions below 180 cm soil depth (Zhang, 1999) and it was assumed that water and nutrient absorbed by roots below this depth would be a small and rare event and that NO_3-N leached below this depth would cause potential of groundwater pollution.

The nutrients losses in the soil from chemical fertilizers and unprecedented prices hike and the unavailability of fertilizers at proper time has also been becoming the matter of serious concern in farming (Kabir, 1999). About 30 to 70% of N applied through nitrogenous fertilizers to agricultural crops is lost due to NH_3 volatilization, denitrification, and NO_3 leaching processes, thus requiring multiple applications to crops. However, Zhang *et al*., (2004) reported that fertilizer N losses due to NH_3 volatilization were markedly higher than those through denitrification and nitrous oxide omissions. Phosphate also becomes immobile and less available to plants, especially under high pH conditions encountered in most of the agricultural soils of Pakistan. Because of such high losses of nitrogenous fertilizers, numerous applications of chemical fertilizers are often required to obtain high crop yields.

Multiple applications of fertilizers are neither economical nor safe for the farmers, and most certainly not healthy for the soil and the environment. This situation is having a considerable impact on crop production, particularly in cereal crops. It is therefore a critical need to design and develop environmentally compatible fertilizers that can limit the loss of fertilizer N, and additionally contain all of the necessary ingredients for superior performance. Keeping in view the importance of fertilizer formulations in nutrient availability, a research project was planed to study the effect of N, P fertilizers and fertilizer formulations (DAP with compost) on maize plant growth.

Materials and Methods

a. Plant material and experimental design: A pot experiment was conducted at Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan on maize plant growth as influenced by seven treatments including four sole fertilizers Urea and DAP @ 50 & 100ppm, two fertilizer formulations (DAP + Compost @ 50 & 100ppm) and control (Table 1). Dera Ismail Khan lies between 31°, 50′ North latitude and 70°, 50′ East longitude. The maize cultivar ‘Azam’ was sown in pots using complete randomized design (CRD) with three replications during March-April, 2009. Four kg of soil was used in each pot and 21 pots were arranged. Maize was fertilized @ 50 and 100ppm N/pot in the form of Urea, DAP and formulations of DAP with compost at the time of sowing. Soil moisture contents were maintained throughout the crop life for 45 days.

Table 1. Fertilizers and fertilizer formulations.

Fertilizer treatments		Rates
T1	Control	-
T2	Urea	50 ppm
T3	Urea	100 ppm
T4	DAP	50 ppm
T5	DAP	100 ppm
T6	DAP + Compost (20:20)	50 ppm
T7	DAP + Compost (20:20)	100 ppm

b. Soil sampling, preparation and analysis: For soil analysis, the soil samples were collected from a depth of 0-15 cm from experimental fields of Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan with the help of augar. The samples were air dried, ground with pestle and mortar and passed through 2 mm sieve. Soil samples were analyzed for soil moisture, texture, pH, electrical conductivity, bulk density, phosphorus, total organic nitrogen and total organic carbon following Peterson & Calvin (1986).

i. Soil moisture: Soil sample were taken in metallic cans and weights were recorded. The samples were dried at 105°C in the oven. Soil moisture in % was calculated according to Gardner (1986).

ii. Soil texture: Soil texture was determined by the Bouyocous hydrometer method of Hussain & Jabbar (1985) using 50 g soil and 10 ml of 1 N Na_2CO_3 as dispersing agent. Soil texture class was determined by using ISSS triangle.

iii. Soil pH: Two buffer solutions of pH 4 and 9 were prepared by dissolving buffer tablets in 100 ml of distilled water. After standardizing the pH meter with buffer solutions, the soil pH was recorded according to US Salinity Lab. Staff (Anon., 1954).

iv. Electrical conductivity: Soil EC (electrical conductivity) was determined according to Rhoades (1982).

v. Bulk density (BD): Bulk density was calculated according to Hussain & Jabbar (1985).

vi. Total organic nitrogen: Total nitrogen in soil samples were determined by the Kjeldahl method of Bremner & Mulvaney (1982).

vii. Total organic carbon: Total organic carbon in the soil samples was determined by the Walkley & Black method (Ryan *et al*., 2001).

c. Compost analysis: The compost used in fertilizer formulation (DAP + Compost) was analyzed for its various properties including pH, moisture content, N, P, K, total organic carbon and organic matter following Peterson & Calvin (1986).

d. Parameters measurement and statistical analysis: The data were recorded on 45 days plants on fresh root weight (g), fresh shoot weight (g), root length (cm), shoot length (cm), dry root weight (g) and dry shoot weight (g). The data were subjected to analysis of variance as outlined by Steel & Torrie (1980) for all the traits, and the treatments were further separated and compared by using the least significant difference (LSD) test.

Results and Discussion

i. Physico-chemical analyses of the experimental soil: The soil particle size analysis indicated that it had 10% sand, 38% silt and 52% clay with textural class clay loam (Table 2). The soil was alkaline in reaction (pH 8.2), non-saline (EC 0.12 dSm^{-1}), having Bulk density of 1.34 g/cm^3 and moisture content (12.30%). The amounts of organic carbon and organic matter content in the surface (0-15 cm) were 0.62% and 0.70%, respectively. The amount of total nitrogen was 0.078% and the available phosphorus was 5.43 $\mu g\ g^{-1}$.

ii. Compost analysis: Compost analysis revealed (Table 3) that it had pH of 8.00, moisture content (14.73%), total N (1.64%), total phosphorus (0.49%) and potassium (2.45%). The total organic carbon contents were 22.50% with organic matter (39.45%).

The character-wise results of different growth parameters are as under.

Fresh root weight: Results regarding maize plant fresh root weight (Fig. 1) enunciated that the treatments manifested significant ($p \leq 0.01$) differences among fertilizers/fertilizer formulations and control (Table 4). Generally, the fresh root weight ranged from 7.50 g (Urea @ 50ppm) to 15.37 g (DAP + Compost @ 100ppm) among treatments. Maximum and statistically at par fresh root weight was observed in two fertilizer formulations i.e., DAP + Compost @ 100ppm (15.37 g) and DAP + Compost @ 50ppm (15.00 g) and were also closely followed by DAP 100ppm (13.57 g). The Urea @ 100ppm and DAP @ 50ppm provided medium fresh root weight (10.10 to 10.53 g, respectively). The urea@50ppm and control exhibited at par and lowest fresh root weight of 7.50 g and 7.87 g, respectively. Results revealed that fertilizer formulations viz., DAP + Compost @ 100ppm and DAP + Compost @ 50ppm performed better in boosting maize growth and provided maximum fresh root and shoot weight. Wang *et al*., (2008) also mentioned that the N supply influenced the growth of the plants, especially the roots. A high N supply significantly inhibited root elongation and was associated with reduced root weight compared to controls and to plants grown with smaller supplies of N. Our results were also in corroboration with findings of Pal (1996), Zhang *et al*., (2000), Irshad *et al*., (2002) and Shah *et al*., (2007).

Fresh shoot weight: Results indicated (Fig. 2 & Table 4) that all the treatments differed significantly ($p \leq 0.01$). Overall, the fresh shoot weight ranged from 22.53 g (Urea @ 100ppm) to 33.93 g (DAP + Compost @ 50ppm) among the treatments. Maximum and statistically equal fresh shoot weight was recorded in two formulations (DAP + Compost @ 50ppm and DAP + Compost @ 100ppm) with values of 33.93 and 33.77 g, respectively. These formulations were followed by the values of DAP @ 100ppm (29.90 g). The control and two treatments (Urea @ 50ppm & DAP @ 50ppm) showed at par and medium fresh shoot weight ranged from 24.93 g and 25.20 g. However, the lowest fresh shoot weight was noticed in Urea @ 100ppm (22.53 g). Irshad *et al*., (2002) also found that composted manure and urea fertilizer enhanced plant growth and nutrient uptake as compared to control. Maize growth was better under urea fertilizer as compared to composted manure. However, Shah *et al*., (2007) authenticated that integrated use of compost and urea at 75:25 or 50:50 ratios (N basis) has produced maximum growth and eventually increase the biological and grain yields.

Table 2. Physico-chemical analyses of the used experimental soil.

Soil properties	Values
Clay %	52.00
Silt %	38.00
Sand %	10.00
Textural class	Clay loam
Bulk density (g cm^{-3})	1.34
pH (Saturated soil paste)	8.20
ECe (dsm^{-1})	0.12
Moisture %	12.30
Nitrogen %	0.078
Organic matter %	0.70
Total organic C %	0.62
Available phosphorus (μg g^{-1})	5.43

Table 3. Chemical analysis of the used compost.

Compost properties	Values
pH	8.00
Moisture content %	14.73
Total nitrogen %	1.64
Total phosphorus %	0.49
Potassium %	2.45
Total organic C %	22.50
Organic matter %	39.45
C:N	15.30

Table 4. Mean squares for various growth traits of maize.

Parameters	Mean squares	C.V.%
Fresh root weight	31.76**	6.11
Fresh shoot weight	64.16**	2.57
Root length	100.32**	2.07
Shoot length	39.47**	0.97
Dry root weight	0.16**	5.88
Dry shoot weight	0.69**	2.06

*, ** = Significant at $p \leq 0.05$ & $p \leq 0.01$, C.V. = Coefficient of variation

Root length: The results concerning root length (Fig. 3) uttered that mean squares (Table 4) showed significant differences ($p \leq 0.01$) among fertilizers/fertilizer formulations. Maximum root length was provided by Urea @ 50ppm (56.33 cm) and closely followed by plants having DAP @ 100ppm and DAP + Compost @ 100ppm with mean values of 48.50 and 46.97 cm, respectively. The control and DAP @ 50ppm manifested lowest root length (39.33 to 40.00 cm). The urea @ 50ppm and DAP @ 100ppm have significant effect on root length as compared to other treatments. Other two treatments expressed medium root length with range of 43.67 to 44.70 cm. It was also observed that none DAP @ 100ppm was found to have 3rd top scoring values for fresh root and shoot weight. Similar results have also been reported by Pal (1996), Zhang *et al*., (2000), Irshad *et al*., (2002) and Shah *et al*., (2007) with significant improvement in maize growth by using composted manure and N as compared to control.

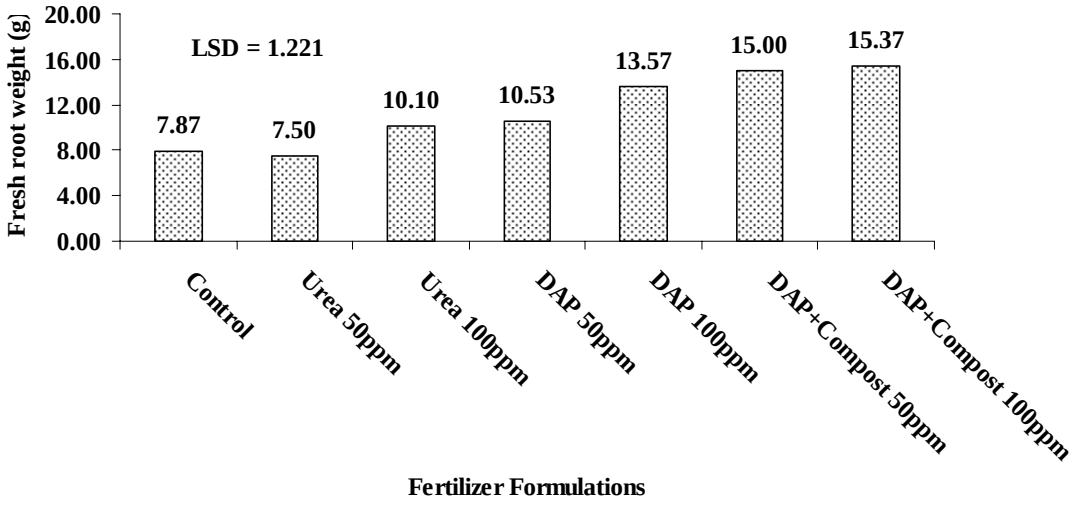

Fig. 1. Effect of different fertilizers and fertilizer formulations on maize fresh root weight.

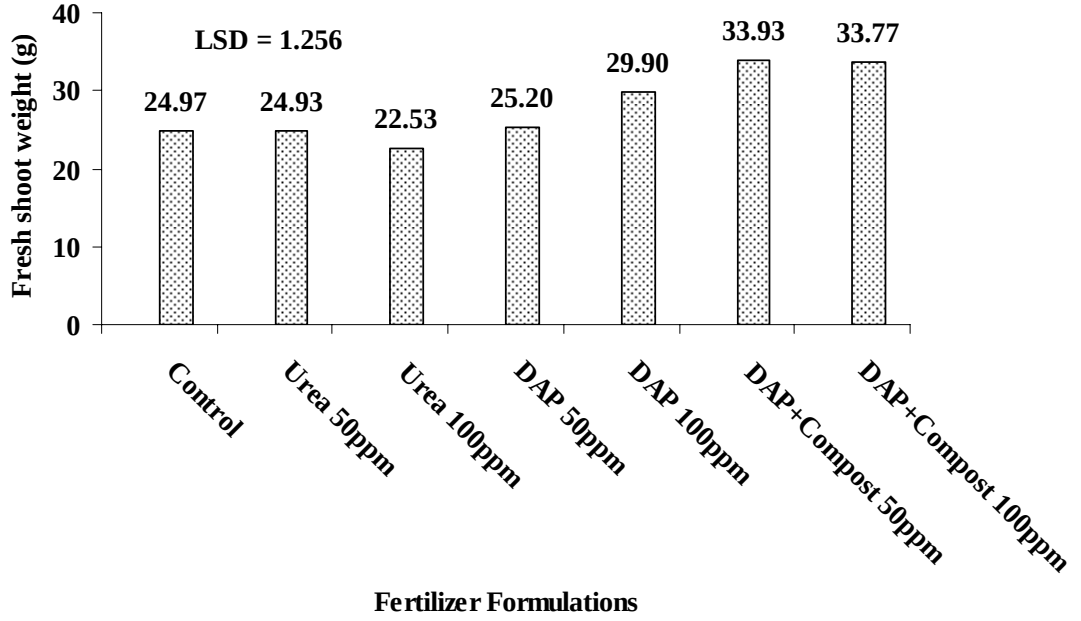

Fig. 2. Effect of different fertilizers and fertilizer formulations on maize fresh shoot weight.

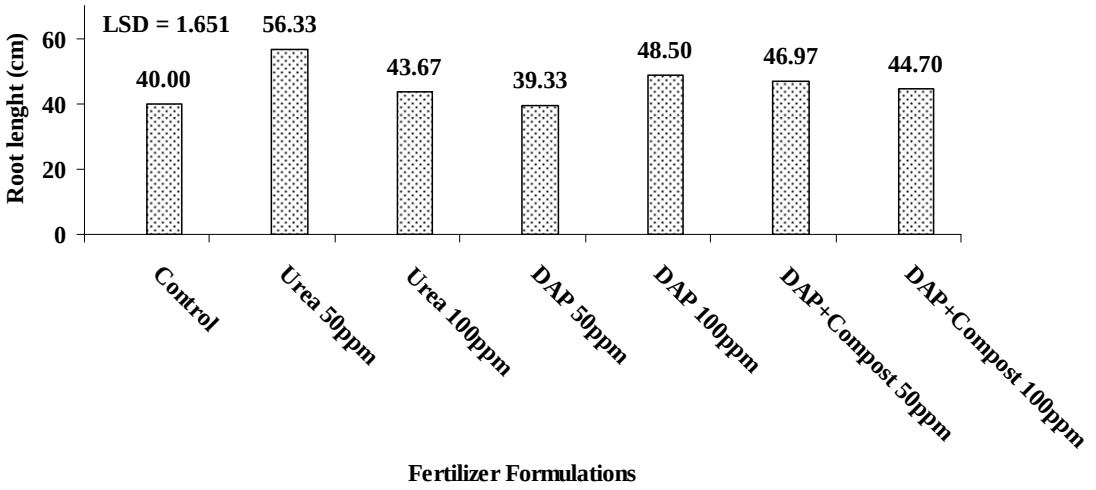

Fig. 3. Effect of different fertilizers and fertilizer formulations on maize root length.

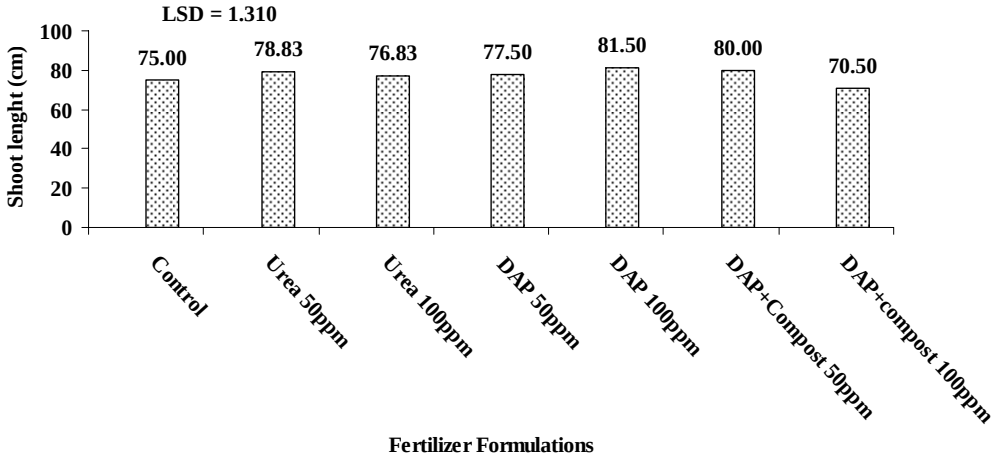

Fig. 4. Effect of different fertilizers and fertilizer formulations on maize shoot length.

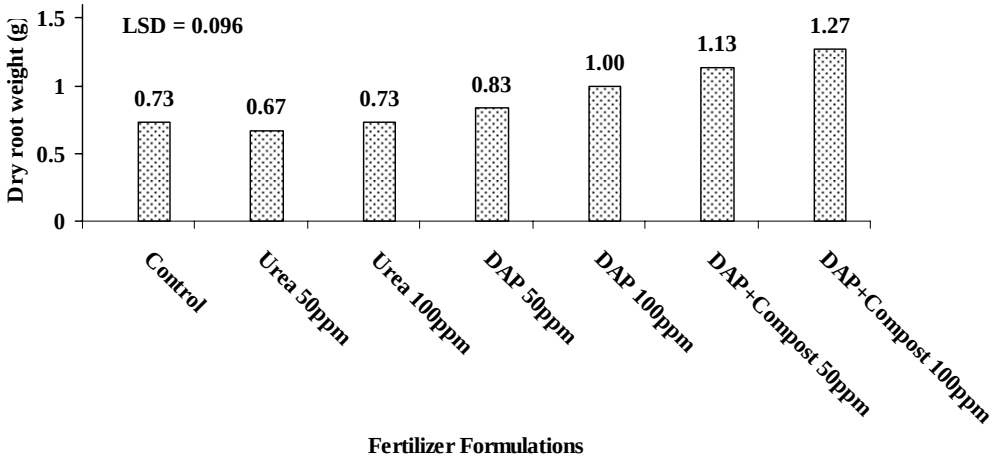

Fig. 5. Effect of different fertilizers and fertilizer formulations on maize dry root weight.

Shoot length: Data concerning maize shoot length (Fig. 4) articulated that there were significant differences ($p \leq 0.01$) among fertilizers and fertilizer formulations (Table 4). However, maximum shoot length (81.50 cm) was recorded in DAP @ 100ppm followed by DAP + Compost @ 50ppm (80.00 cm) and Urea @ 50ppm (78.83 cm). Minimum shoot length was observed in control (75.00 cm) and DAP + Compost 100ppm (70.50 cm). The remaining treatments revealed medium type of shoot length. Results further revealed that DAP @ 50ppm and DAP + Compost @ 50ppm had almost similar impact on maize shoot length as in other growth parameters. The findings were in confirmation with the observations of Zhang *et al.,* (2000), Irshad *et al*., (2002) and Shah *et al*., (2007) as they also noticed that composted manure and N/P fertilizer enhanced plant growth and nutrient uptake as compared to control.

Dry root weight: Results regarding maize dry root weight (Fig. 5) revealed that treatments manifested highly significant ($p \leq 0.01$) differences (Table 4). Overall, the dry root weight ranged from 0.67 g (Urea @ 50ppm) to 1.27 g (DAP + Compost @ 100ppm). Data further revealed that maximum dry root weight (1.27 g) was observed in DAP + Compost @ 100ppm having significant difference as compared to other treatments. It was also followed by DAP + Compost 50ppm (1.13 g). The control and two formulations (Urea @ 50 & 100ppm) exhibited minimum dry root weight ranged from 0.67 to 0.73 g. Other treatments showed medium dry root weight. It was also observed that formulations DAP + Compost @ 100ppm and DAP + Compost @ 50ppm performed better in enhancement of maize growth and provided maximum root biomass.

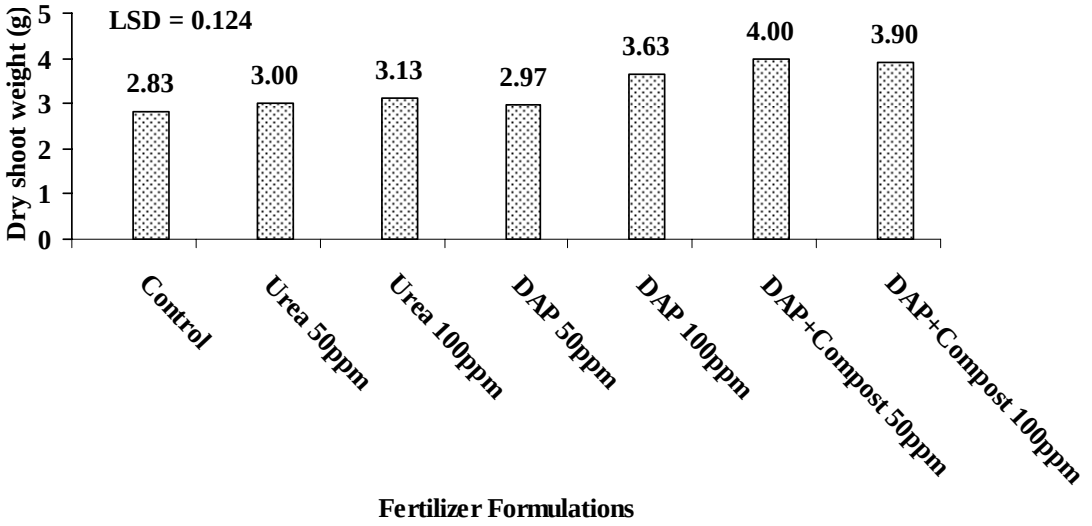

Fig. 6. Effect of different fertilizers and fertilizer formulations on maize dry shoot weight.

Dry shoot weight: Mean squares for dry shoot weight (Fig. 6) revealed significant differences ($p \leq 0.01$) among fertilizers/fertilizer formulations and control (Table 4). Generally, the dry shoot weight ranged from 2.83 g (control) to 4.00 g (DAP + Compost @ 50ppm) among the treatments. Results further exhibited that maximum and statistically at par dry shoot weight was achieved in two formulations which ranged from 3.90 g (DAP + Compost @ 100ppm) to 4.00 g (DAP + Compost @ 50ppm). These treatments were followed by maize plants with DAP @ 50ppm (3.63 g). However, the least dry shoot weight was recorded in control (2.83 g). Other three treatments exhibited medium dry shoot biomass ranged from 2.97 to 3.13 g. It was also concluded that formulations DAP + Compost @ 50 and 100ppm performed better in boosting maize growth and provided greater shoot biomass. The N supply influenced the maize growth and especially the roots (Pal, 1996; Zhang *et al*., 2000; Irshad *et al*., 2002; Shah *et al*., 2007; Wang *et al*., 2008).

Conclusion: The fertilizer formulations (DAP + Compost @ 50ppm and DAP + Compost @ 100ppm) performed better and significantly enhanced the maize growth as compared to sole fertilizers.

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(Received for publication 4 May 2009)